Description

Method for radio system resource management

5   The invention relates to a method for radio system resource
     management in a cellular radio communication system configured
     as a multiple-carrier network in accordance with the preamble
     of claim 1.

10   The invention also relates to a radio communication system
     with a cellular construction in accordance with the preamble
     of claim 13 and a control device for a radio communication
     system in accordance with the preamble of claim 14.

15   In radio communication systems, information (for example
     voice, image information, video information, SMS (Short
     Message Service) or other data) is transmitted with the aid of
     electromagnetic waves via a radio interface between
     transmitting and receiving stations. The radiation of
20   electromagnetic waves in this case takes place at carrier
     frequencies that lie within the frequency band provided for
     the particular system. A radio communication system in this
     case includes subscriber stations, e.g. mobile stations, base
     stations, e.g. node B's and other network devices. The
25   subscriber stations and base stations are connected to each
     other in a radio communication system via an interface.

     Access by stations to the common transmission medium in these
     radio communication systems is controlled by multiple access
30   (MA)/multiplexing methods. With these multiple accesses, the
     transmission medium can be divided between the stations in the
     time domain (Time Division Multiple Access, TDMA), in the
     frequency domain (Frequency Division Multiple Access, FDMA),
     in the code domain (Code Division Multiple Access, CDMA) or in

the space domain (Space Division Multiple Access, SDMA). In
this case, a subdivision of the transmission medium frequently
takes place into frequency and/or time channels corresponding
to the radio interface (for example with GSM, TETRA
5   (Terrestrial Trunked Radio), DECT (Digital European Cordless
Telephone), UMTS). Combinations of several of these methods
are also used. To enable an economical use of the scarce radio
resources, radio communication systems are provided with
devices, such as control devices that manage radio system
10 resources or assign resources. The resource of a radio
interface in this case can, for example, be a time slot-
frequency pair or also only one of the two (time slot or
frequency).

15 Due to the increasing data rates, particularly in mobile radio
systems, the bandwidth required steadily increases. To
guarantee transmission of information that is as efficient as
possible, the complete frequency band available is broken down
into several sub-carriers (multiple carrier methods). The idea
20 on which the multiple carrier systems, also known as OFDM
(Orthogonal Frequency Division Multiplexing) is based, is to
shift the initial problem of the transmission of a wideband
signal to the transmission of a set of narrowband orthogonal
signals. This also has the advantage that the complexity
25 required at the receiver can be reduced.

With OFDM, pulse shapes that are almost rectangular are used
for the sub-carriers. The frequency spacing of the sub-
carriers is chosen in such a way that at the frequency at
30 which the signal of a sub-carrier is evaluated the signals of
the other sub-carriers are at zero crossing. This means that
the sub-carriers are orthogonal relative to each other. A
spectral overlapping of the sub-carriers and resulting high
packing density of the sub-carriers is permissible because the

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orthogonal arrangement means that distinguishability between the individual sub-carriers is ensured. A spectral efficiency that is better than with the simple FDM (Frequency Division Multiplexing) is thus achieved.

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The smallest geographical radio coverage area of a cellular radio communications system is called a radio cell. This area is served from a base station. The form of the radio cell is optimized so that a periodically recurring structure results.

10   If a transfer to a different base station takes place during an active connection between a subscriber station and a base station, this is known as a handover. Performing a 'seamless' handover means that communication can be continued without interruption, if, for example, the subscriber station moves

15   from one radio cell to an adjacent radio cell. The handover procedure can take place either from the base station or from the subscriber station. A handover is, e.g. triggered if the signal received from the subscriber station no longer ensures a proper transmission, or if the signal from a different base

20   station is received with a greater amplitude than that from the base station currently connected to the subscriber station via the radio interface. A threshold value is used for this purpose, in order to avoid instabilities, such as the ping-pong effect.

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With cellular radio communication systems there is a radio cell concept in the form of a honeycomb plan, for the optimum utilization of the radio frequencies, whereby the radio frequencies or the frequency band is used in other cells.

30   This is expressed by the frequency reuse factor. By maintaining a certain protective distance before the reuse of a frequency, a frequency reuse factor is used that is greater

than one. A frequency reuse factor of one corresponds to a
case where each frequency uses the same frequency band.

Document WO 02/49385 A2 describes an OFDM system with a
5   frequency reuse spacing of 1. The cells can be divided into
sectors with each sector using one OFDMA cluster, so that the
frequency reuse spacing between the clusters is 2.

Document "W.S. Kim, V.K. Prabhu: Enhanced Capacity in CDMA
10   Systems with Alternate Frequency Planning, Communications
1998. ICC 98, Conference Record, 1998 IEEE International
Conference on Atlanta, GA, USA 7-11 June 1998, pages 973-978,
ISBN: 0-7803-47788-9, XP010284782" presents various frequency
planning schemes for CDMA systems. According to these, a
15   frequency reuse spacing of 1 or a frequency reuse spacing of 3
is possible, or the cells can be divided into areas so that
different areas of the cells use different parts of the
frequency band.

In existing mobile radio systems of the second generation with frequency reuse factors greater than one, a subscriber station changes the carrier frequency in order to measure the

5   amplitudes of the radio signals of another adjacent base station. If the actual received amplitude of the particular base station with which the subscriber station is in communication is greater than the measured amplitude of an adjacent station by a set threshold, a handover to a different

10 base station is initiated. In systems of this kind, the subscriber station must measure all amplitudes received from the adjacent stations, in that it selects the relevant frequency and interrupts the connection to the supplying base station during the measuring procedure. This normally occurs

15 in the periods in which there is no communication between the subscriber station and the particular base station, i.e. during so-called idle periods, so that a base station is unaware of the measurement by a subscriber station. Alternatively, a subscriber station can log off from the base

20 station for these purposes, e.g. as provided by HIPERLAN/2. Measurements by the subscriber station on other frequencies requires time and signaling resources.

In the UMTS (Universal Mobile Telecommunications System) the

25 mechanism of the soft-handover with macro diversity is used. A feature of this is that the same information signal is sometimes transmitted simultaneously from several base stations but with different spread factors. The subscriber station receives, decodes and combines all signals and is

30 therefore able to increase the quality of reception. The disadvantage of this method is that several resources have to be used for the same information.

As a rule it can be assumed that the number of frequency bands per operator in the OFDM systems is limited to a single frequency band. Therefore every effort is made to use the available frequency band effectively. Because only a single

5   frequency is available to the operator, a frequency reuse factor of one is present. To reduce the interference and amount of signaling, efficient handover methods are required.

The object of the invention is to provide an effective method

10   of the management of radio resources of the type named in the introduction and to demonstrate a corresponding radio communication system and control device of the type named in the introduction.

15   This object is achieved with regard to the method by a method with the features of claim 1.

Embodiments and developments are the object of subclaims.

20   In accordance with the invention, the sub-carriers of the at least one frequency band of each radio cell are temporarily available for the transmission of information, and the several sub-carriers of the at least one frequency band are temporarily assigned to a number of radio cells in such a way

25   that each of the assigned sub-carriers is available to a subset of the number of radio cells for transmission of information.

The number of radio cells in this case consists of at least

30   two radio cells. A subset of this number must contain fewer radio cells than the total number.

An advantage of this method is that in principle a frequency reuse factor of one can be used. For many channels, such as

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certain broadcast channels, resources can, however, be saved
if the sub-bands are not allowed to be used by all base
stations. The invention enables the intensive utilization of
resources with a frequency reuse factor of one in conjunction
5   with a distribution of resources to the base stations for
specific purposes.

In a development of the invention, at least one of the
assigned sub-carriers is available to exactly one radio cell
10   from the number of radio cells. It is also possible that each
of the assigned sub-carriers is available to precisely one
radio cell from the number of radio cells. Overall, therefore,
by means of the assignment each sub-carrier can be available
to one or more radio cells from the number of radio cells, but
15   not to all radio cells. Different sub-carriers can be
simultaneously assigned different and different numbers of
radio cells.

Advantageously, the number of radio cells consists of adjacent
20   radio cells. Radio cells are adjacent if they have a common
boundary. In a network of hexagonal radio cells, each radio
cell therefore has six neighboring radio cells. In a network
of this kind, the number of radio cells consists
advantageously of seven radio cells. A different number of
25   radio cells is also possible.

In the assignment of the sub-carriers to n radio cells at
least one sub-carrier available to a radio cell can
advantageously have a frequency spacing of n sub-carriers. If
30   the number of radio cells, for example, amounts to seven radio
cells, the first sub-carrier, the eighth sub-carrier, the
fifteenth sub-carrier, etc., can be assigned to the first
radio cell. In each case, the nth sub-carrier is thus assigned
to the particular radio cell. It is possible that in addition

to the assignment of sub-carriers described, further sub-carriers can be available to a radio cell, so that not all sub-carriers have a frequency spacing of n sub-carriers. Thus, for example, the first and the second, the eighth and the

5   ninth, the fifteen and sixteenth sub-carriers, etc. can be assigned to one radio cell.

In one embodiment of the invention, in the assignment of the sub-carriers, subcarriers available to at least one radio cell

10   are sub-carriers adjacent in the frequency band. For example, sub-carriers one and two can be assigned to the first radio cell from the number of radio cells, sub-carriers three and four, etc. can be assigned to the second radio cell, with the numbering of sub-carriers increasing with increasing

15   frequency. It is also possible to combine an assignment of adjacent sub-carriers and sub-carries with a frequency spacing.

In a development of the invention, the sub-carriers are

20   assigned in accordance with an algorithm. Any rule for computing a numerical value that maps the number of sub-carriers to the number of radio cells, whereby only a subset of the number can be assigned to each sub-carrier, may be used. An example of an algorithm is the assignment of sub-

25   carriers in accordance with codes. Thus, where there are four sub-carriers, the code 1,0,1,0 for example, means that the first and second sub-carriers are assigned to the particular radio cell. A method of this kind can be used in the context of the MC-CDMA (Multi Carrier Code Division Multiple Access)

30   method.

Advantageously, the assigned sub-carriers are used by the base stations of the particular radio cells to transmit broadcast information. The broadcast information can be advantageously

used to decide on handovers. A handover decision usually takes place depending on one or more measured values. These include, for example, measured values of the intensities of the broadcast channels transmitted from the base station. A

5   decision as to whether a handover is to take place or not can then be made depending upon the result of the measurement. Where the handover decision is positive, a decision can be made as to the cell to which the handover is to take place.

10   In a development of the invention, the amplitudes of the broadcast information are determined in subscriber stations receiving the broadcast information. Advantageously, a metric of the amplitudes of the broadcast information transmitted from a base station on the sub-carriers available to it is

15   determined. A metric can, for example, be a mean value. The metric can be determined either in the subscriber station or in the base station, or in a different device in the network. If the determination is not made in the subscriber station, the result of the measurements of the amplitudes must be

20   transmitted from the subscriber station to the network.

The method can advantageously be used on an OFDM system.

With regard to the radio communication system of cellular

25   construction, the aforementioned objective can be achieved by a radio communication system with the features of claim 13.

The radio communication system of cellular construction has at least one control device in the network. In accordance with

30   the invention, the at least one control device in the network has

-      means of at least temporarily assigning the several sub-carriers of the at least one frequency band to the radio cells in such a way that the sub-carriers are available

to each radio cell for the transmission of information, and

- means for the temporary assignment of the several sub-carriers of the at least one frequency band among a number of radio cells in such a way that each of the assigned sub-carriers is available to a subset of the number of radio cells for the transmission of information.

With regard to the control device for a radio communication system of cellular construction, the aforementioned objective is achieved by a control device with the features of claim 14.

In accordance with the invention, the control device has

- means for the temporary assignment of the several sub-carriers of the at least one frequency band to the radio cells in such a way that the sub-carriers are available to each radio cell for the transmission of information and

- means for the temporary assignment of the several sub-carriers of the at least one frequency band among a number of radio cells in such a way that each of the assigned sub-carriers is available to a subset of the number of radio cells for the transmission of information.

Means and devices for the performance of the steps of the method in accordance with the invention according to claim 1 and the embodiments and developments of the invention can be provided in the radio communication system in accordance with the invention and/or in the control device in accordance with the invention.

Particulars and details of the invention are explained using
an example of an embodiment using illustrations. These are as
follows:

5   Fig. 1:   Schematic extract of a cellular radio communication
              system,

    Fig. 2:   An OFDM frame in accordance with the invention,

10 Fig. 3:   Signal amplitudes transmitted from base stations,
              and

    Fig. 4:   Signal amplitudes received from a subscriber
              station.

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The following example of an embodiment is a cellular OFDM
radio communication system, synchronized with regard to time
and frequency. A frequency band with a frequency reuse factor
of one is used in this case. Fig. 1 is a schematic of an
20 extract from a cellular system of this kind with three
hexagonal radio cells. A subscriber station MS_n moves along a
path $\vec{v}$. At its actual stopping point, it receives signals from
a first base station BS_1, from a second base station BS_2 and
from a third base station BS_3. The subscriber station MS_n is
25 actually connected to the third base station BS_3 corresponding
to its location. The arrows of different thicknesses show the
received amplitude of the signals originating from the
particular base station BS_1, BS_2 and BS_3. It can be seen that
although the subscriber station BS_n is located in the cell of
30 the third base station BS_3, the received amplitude of the
signals transmitted from the second base station BS_2 is
greatest. This effect can, for example, occur due to shadowing
and multipath propagation. In the circumstances shown in Fig.

1, it is most favorable if a handover takes place from the third base station BS_3 to the second base station BS_2.

A control device SE is part of the radio communication system.
5   It is (not shown in Fig. 1) connected directly, or indirectly i.e. via other stations, to the base stations BS_1, BS_2 and BS_3. It can also have a connection to the core network (not illustrated). The control device SE can have any spatial position within the radio communication system. It can also be
10   integrated into other devices in the network. The purpose of this control device SE is to assign the radio resources to the different radio cells. It thus decides which sub-carriers are assigned to each individual base station BS_1 , BS_2 and BS_3 or whether they are available to only part of the base stations.
15   These decisions are then transmitted to the base stations.

Fig. 2 shows an OFDM frame, OFDM Frame. The OFDM symbols are shown on the horizontal axis that corresponds to the time axis. The individual OFDM symbols of a frame OFDM Frame can be
20   assigned to different functions. The illustration shows the use of one symbol for signaling information Control, the use of three symbols for useful information Traffic and the use of one symbol for the broadcast BCH of the particular base station. Other uses of the symbols are however also possible.
25   The OFDM symbols are transmitted in succession. Thus, Fig. 2 shows, before the start of the OFDM frame, OFDM Frame, within which the first symbol for useful information Traffic is used, an OFDM symbol of the preceding OFDM frame that is used for the broadcast BCH.
30

An OFDM symbol consists of several sub-carriers ST1, ST2, ST3, ST4, ST5 and ST6, that are shown on the vertical axis of Fig. 2. The example shows six sub-carriers. The designation of the

six sub-carriers ST1, ST2, ST3, ST4, ST5 and ST6 is entered in
the right of the two symbols used for the broadcast BCH.

The broadcast information is transmitted from the base
5   stations, so that handover decisions can be made with the aid
of measurements of amplitudes received from the subscriber
stations. As part of this, the channel quality of the various
base stations located in the vicinity of the subscriber
station is estimated. To do this, it is necessary to know
10   which base station the received broadcast signal originates
from. A possible solution to this problem is to provide a
separate OFDM symbol for broadcast transmission for each base
station. With regard to the time sequence, this corresponds to
the transmission, in succession, of broadcast signals of the
15   various base stations. Therefore, the duration of a few OFDM
symbols must extend until all the information required for a
handover can be transmitted and processed. Furthermore, during
this broadcast, the scarce radio resources use symbols
exclusively for signaling information and not for useful
20   information.

In accordance with the invention, adjacent base stations use
the same OFDM symbol to transmit their broadcast information.
The sub-carriers ST1, ST2, ST3, ST4, ST5 and ST6 of this
25   symbol are assigned to these base stations for this purpose.
In the simplified example with three radio cells shown in Fig.
1, the first base station BS_1, for example, transmits in the
first sub-carrier ST1, the second base station BS_2 in the
second sub-carrier ST2, the third base station BS_3 in the third
30   sub-carrier ST3 and again the first base station BS_1 transmits
in the fourth sub-carrier ST4, the second base station BS_2
again the fifth sub-carrier ST5, etc. Each base station thus
transmits on every third sub-carrier. In the left of the two
OFDM symbols, shown in Fig. 2, used for the broadcast BCH, the

base stations BS_1, BS_2, BS_3 assigned to them are entered in the
sub-carriers ST1, ST2, ST3, ST4, ST5 and ST6. There is then a
gapless OFDM symbol for the subscriber station. This method
can be easily used for several cells. Because of this

5   staggered arrangement, the subscriber station obtains from
only one OFDM symbol information regarding the received
amplitude of the radio channels of adjacent base stations.

Within the network formed by the radio cells, clusters of

10 adjacent cells are combined, to which the sub-carriers ST1,
ST2, ST3, ST4, ST5 and ST6 are then assigned. This cluster
repeats itself periodically in the network of radio cells.
Advantageously, the assignment of the sub-carriers ST1, ST2,
ST3, ST4, ST5 and ST6 takes place in the same way in each

15 cluster. It is, however, also possible to use different
assignment methods in different clusters.

The described method of assignment of the sub-carriers ST1,
ST2, ST3, ST4, ST5 and ST6 to the adjacent base stations BS_1,

20 BS_2, BS_3 is only an example. Further variations of this are
conceivable and can be used depending on the application.
Furthermore, the mode of assignment can also vary over time.
Thus, for example, the assignment shown in Fig. 2 can take
place in a first OFDM frame OFDM Frame, and in the succeeding

25 OFDM frame OFDM Frame the assignment can take place offset by
one sub-carrier, so that a rotation of the sub-carriers ST1,
ST2, ST3, ST4, ST5 and ST6 assigned for the broadcast BCH
takes place over time.

30 The dimensioning of an OFDM system means that adjacent sub-
carriers are correlated. If a sub-carrier is heavily
attenuated by multi-path propagation, this mainly affects one
group of adjacent sub-carriers. It is, however, possible that
the remaining sub-carriers are just slightly attenuated. If

therefore, only one associated group of adjacent sub-carriers
is used as a basis for the broadcast information, only a
limited objective estimation of the channel quality based on
amplitude measurements is possible. With the method described

5   above, the supporting values for determining the channel
quality are distributed over the complete bandwidth of the
frequency band, which makes sure that the accuracy of the
estimation of the channel quality is increased.

10   To be able to effectively estimate the channel quality, the
base stations must transmit on each sub-carrier at a fixed
amplitude known to the subscriber stations. Fig. 3 shows the
amplitude of the broadcast signals transmitted from the
various base stations BS_1, BS_2, BS_3. In accordance with the

15   assignment of the sub-carriers ST1, ST2, ST3, ST4, ST5 and ST6
to the three base stations BS_1, BS_2, BS_3, shown in Fig. 2, the
first amplitude corresponds to the first amplitude used by the
first base station BS_1 on the first sub-carrier ST1, the second
amplitude corresponds to the amplitude used by the second base

20   station BS_2 on the second sub-carrier ST2, etc. Due to multi-
path propagations and shadowing, a subscriber station, for
example, receives a signal, the amplitude of which is shown in
Fig. 4. The amplitudes of the individual sub-carriers ST1,
ST2, ST3, ST4, ST5 and ST6 in this case vary according to the

25   frequency dependency of the attenuation. By means of a simple
averaging, a metric can be formed on the basis of which the
decision for a handover can be derived. To do this, for
example, the amplitudes of all broadcast signals of a base
station are added and this total is divided by the number of

30   sub-carriers used by this base station for broadcast
transmission.

The method can then also be advantageously used if a sub-
carrier is assigned to several radio cells for the broadcast

transmission. In this case, the separation of the signals of
the individual base stations can e.g. take place by means of a
specific code.

5   Overall, the provision of the information necessary for the
handover decision was reduced to a single OFDM symbol of the
signaling expenditure. This serves as a basis for reducing
interference and enabling a higher spectrum efficiency.